

Backgrounder

DOE and National Laboratories Define "Roadmap" to Push Development of Robotic and Intelligent Machines Technology Through the Year 2020

Setting the Stage...

"The Congressional Expo demonstrated that the U.S. robotics and intelligent machines industry is on the cusp of major advances. The United States currently leads the world in enabling technologies such as software, sensors, and controls. These next generation technologies are opening the door to new markets and may enable the United States to regain its dominant position in the robotics and intelligent machines industry."

Senate Task Force on Manufacturing, 1997

In 1997 the Robotics and Intelligent Machines Coordinating Council (RIMCC) sponsored, at the request of Congress, an exposition of robotics and intelligent machines technology in Washington, DC. As a result of what they saw, Senators Lieberman, Snowe, Bingaman, Domenici, D'Amato, and Congressmen Franks and Meehan, sent a letter to the Secretaries of Defense, Energy, and Commerce, the Administrator of NASA, and the Director of the National Science Foundation endorsing an eight point program to advance the state-of-the-art in robotics and intelligent machines. These agencies are major sponsors of robotics research and development (R&D), in large part because they face complex and sometimes hazardous technical challenges as part of accomplishing their missions. In many instances robotics technology offers these agencies the only sufficiently safe, cost-effective, and/or accurate solutions.

The U.S. Department of Energy (DOE) took the lead for RIMCC in responding to the challenge issued by Congress, and through a 6-month collaborative effort by a team of DOE representatives, national laboratory scientists and with input from DOE plants and sites, defined for the first time a DOE research and development path for robotics and intelligent machines technology. The result, ***Robotics and Intelligent Machines in the U.S. Department of Energy: A Critical Technology Roadmap***, was published in October 1998. It traces the connection between DOE's multiple mission needs (e.g., the need to protect workers from the hazards of radioactive, explosive, toxic and other materials, or to create ever more precise parts and coatings) and the future of robotics science and technology (S&T) from today through the year 2020. The *Roadmap* describes in detail how advances in robotics and intelligent machines will

The Roadmap is available from the Intelligent Systems and Robotics Center at Sandia National Laboratories and is on the internet at www.sandia.gov/ISRC.

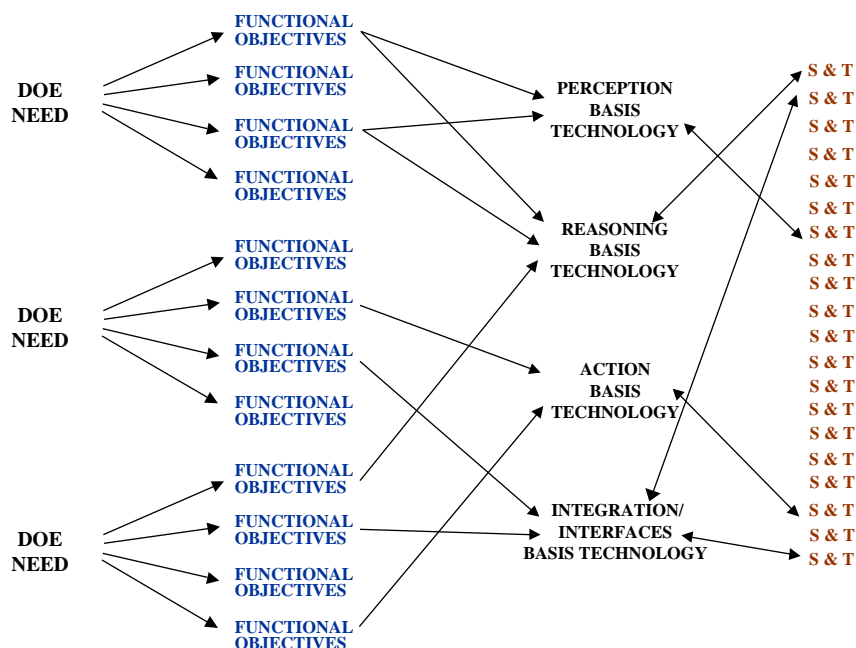
revolutionize DOE's manufacturing, hazardous and remote operations, and monitoring and surveillance activities.

What is a Technology Roadmap?

Technology roadmaps serve as pathways to the future. They call attention to future needs for development in technology, provide a structure for organizing technology forecasts and programs, and communicate technological needs and expectations among end-users and the R&D community.

The purpose of the *Roadmap* developed by DOE and its national laboratories is to identify, select and develop R&D objectives that will satisfy the near- and long-term challenges posed by DOE's missions. Development of the *Roadmap* began with a discussion of DOE's major needs in the 2004, 2012 and 2020 timeframes. From this, the Roadmapping Team identified Functional Objectives—specific capabilities DOE will need to meet its goals, and to which robotics and intelligent machines technology can contribute significantly. As part of this process, the team described four basis technology areas, (perception, reasoning, action and integration/interfaces) that underlie robotics and intelligent machines R&D, and identified individual applications thus mapping the pathway a technology will follow for incorporation into DOE operations. This concept is illustrated below:

Robotics and Intelligent Machines Technology Roadmap *From Needs to Science and Technology*



For the first time, the *Roadmap* provides a framework through which one can see how R&D across the entire spectrum of basis technology areas will contribute to the development of robotic systems that will meet DOE's needs. The identification of Functional Objectives and their

associated timeframes serve as guideposts for end-users and the R&D community to anticipate technological needs and capabilities over the next twenty years.

The Future of RIM in the U.S. Department of Energy...

Over the next few decades, advanced RIM technologies will fundamentally change the manner in which people use machines, and by extension, the way DOE accomplishes its missions. New robotic systems, fueled by improvements in computing, communication and micro-engineered technologies, will transform many of our most difficult tasks. It is expected, for example, that:

- Automated methods closely coupling design and manufacturing will allow cost-effective, totally automated manufacturing of both large- and small-lot products;
- Microscale robots with the ability to crawl, fly, and swim will be able to work together to perform monitoring, surveillance and intelligence operations; and
- Environmental facility remediation, monitoring and inspection, as well as resource exploration will be performed with high efficiency and low risk by autonomous teams of robots;.

In the future, people will work directly with teams of cooperating robots in complete safety and will interact with multiple intelligent machines through sensory, immersive interfaces that intelligently adapt to human and supervisor desires. Health monitoring and maintenance will be fully automated. Power sources and communications will no longer inhibit missions, and all robotic systems will be constructed and configured through fully automatic plug-and-play approaches. By the year 2020, intelligent machines will both duplicate and extend human dexterity, perception, and work efficiencies in broad ranges of tasks—these technologies will be as pervasive and indispensable in DOE operations and the national economy as the personal computer is today.

Making the Connection to U.S. Industry and Universities

It is in providing this sweeping view of the future of robotics and intelligent machine capabilities and their applications within DOE that the *Roadmap* serves its primary function. Through the *Roadmap* RIMCC presents an understandable, credible, and common vision of how these technologies will evolve over the next two decades to lower costs, improve safety, and increase productivity for DOE. However, the *Roadmap* also provides the basis for concrete discussion of connections between DOE's needs, the R&D it supports, and complementary efforts at universities and within private industry. While robotic systems have not always been associated with cost savings, increased flexibility and worker safety, members of RIMCC believe strongly that the combination of past investments in robotics science and technology as well as the recent spectacular advances in computing, communications, electronics, and micro-engineering, leave the technology poised to provide DOE and other Federal Agencies with a dramatically new set of tools at their disposal.

In 1998, DOE sponsored approximately \$28.6 million in robotics R&D and is considering increasing that amount substantially beginning in FY01. Furthermore, RIMCC anticipates that its roadmapping activities will expand to involve the activities of the other Federal agencies mentioned in the Senate Task Force on Manufacturing letter. Because these investments will create as well as eliminate technological opportunities in the future, it is crucial that U.S. Government agencies and their laboratories, plants and sites work closely with U.S. universities and industry to ensure that U.S. robotics and intelligent machines technology remains at the forefront of this new industry.

Interaction Between Technology Developers, Users and Suppliers

